

STRESS ANALYSIS OF THE VARIOUS DIMENSIONS OF THE SPRING

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ABSTRACT

This report deals with propose of new dimension of the spring to the suspension system. The objective of this project is to analyze the effect of the spring performance when we modified the dimension of the spring. The new design of the spring will be drawn by using SolidWorks® software. Then this a few dimension of the spring will be testing by using MSC. Nastran/Patran software. This software was used to analyze the stress on the different dimension of the springs. The stress results of the different dimensions were observed and recorded. The stress values indicated that the one of the new dimension of the spring can withstand the highest stress compared to the other spring.

ABSTRAK

Laporan ini membincangkan dengan mencadangkan dimensi baru spring kepada sistem suspensi. Objektif projek ini adalah untuk menganalisis kesan prestasi pegas apabila kita mengubah suai dimensi pegas. Reka bentuk baru pegas akan dilukis dengan menggunakan perisian SolidWorks®. Kemudian ini dimensi beberapa pegas akan diuji dengan menggunakan MSC. Perisian Nastran / Patran. Perisian ini telah digunakan untuk menganalisis tekanan pada dimensi yang berbeza, pegas. Keputusan tekanan dimensi yang berbeza diperhatikan dan direkodkan. Nilai tekanan yang menyatakan bahawa salah satu dimensi baru pegas boleh menahan tekanan yang tertinggi berbanding dengan pegas lain.

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LIST OF SYMBOLS

f	Stress in the material
E	Young's modulus
G	Shear modulus
X	Maximum allowed displacement amplitude
ω	Angular frequency
VD	Vibration dose value
a	Acceleration
d	Density
t	Time

LIST OF ABBREVIATION**Name**

2.1	Chromium steel	(Cr)
2.2	Chrome iron	(FeCr ₂ O ₄)
2.3	Crocoisite	(PbCrO ₄)

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Suspensions, as many other vehicle systems, followed relatively closely the evolution of the transportation technology. For centuries carts were not equipped with any sort of suspension at all. Only later, in the eight century, was a primitive suspension based on an iron chain system developed.

Metal springs were first developed in the 17th century and shortly afterwards leaf springs. Various designs were developed until the last century, which saw the development of the concept of suspension based on a spring and a damper.

Actually what exactly the suspension does at our vehicle? The suspension determines how smooth or rough the car ride will be. That is the reason why some vehicles are very smooth and others are bumpy. A good suspension system will let the car hug corners effortlessly and let the passenger drink without worrying of making a spill.

So, we need make a few design of spring with different dimension. Besides that, we still consider the parameter of spring. So that, we able to get the better result for the dimension spring.

In this project, we decide to design a new spring which is we consider dimension of the spring. Then, we use the software that required to analysis the spring to gathering data. From that, we will be able to choose the best dimension for the spring. This is may be used as in the automotive industry in the future plan maybe. To improve the automobile comfortable and try to fulfill the customer needed with concern the safety and comfortable for user of vehicle.

1.2 PROBLEM STATEMENT

The problem that we must face are when the car bumping roughly. It will make the headache that passenger will became worst. When you need to the long journey when your car through the deep shallow did the water from your drink will spill out.

Because of these problems, we make a few design of the spring but only consider about the dimension. Which we consider a few part of the dimension of spring we need to change. We specific the value of the dimension of the spring we need to change. The effect of the suspension performance must be related with the dimension of the spring. To get the good performance of suspension system it must have a good characteristic of the spring.

1.3 OBJECTIVE

The objective for this project is to identify the effect of the spring dimensions.

1.4 PROJECT SCOPE

What I need to do to get the objective:

- 1) Model the spring with different dimension using SolidWorks[®] software.
- 2) Perform stress analysis using MSC. Nastran/Patran software.

1.5 Organization of thesis

This thesis has been written with necessary details to the understanding of this project. Excluding the introduction, which is the first chapter for this thesis, the main point of this project is divided into four chapters.

Literature review is the several previous studies on suspension system and the effect of change it dimension for previous research, Chapter 2. Chapter 3, about the changed the dimension of spring which is we need to consider about the original dimension and specific spring of vehicle. Chapter 4 is the results of the analysis are recorded. Lastly is Chapter 5, it presents the conclusion of overall study and the future work recommendation.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The aim of this chapter is to provide all the information of suspension system. How did the change the dimension of the spring will affect the performance of the suspension system of our vehicle? What is the good dimension of the spring? The suspension system will be discussed thoroughly in this chapter. Various sources including journal, thesis, reference books and literature reviews have been carried out and revised in writing this chapter.

2.2 SUSPENSION SYSTEM

What is the function of the suspension system? Historically, buses were no more than special-bodied trucks, sharing the same simple suspension systems and the priority for low cost of operation. Over the years, passenger demand has required improvement in chassis and suspension design to deliver improved and consistent comfort over a wide range of loads, as with cars.

Nowadays, this technology is beginning to transfer to cargo-carrying vehicles, notably to the semi-trailers. Sometimes, this is driven by particular customer needs for transport of fragile cargo, but often by legislative requirements, such as to minimize road damage. Besides that, the suspension system is used to support a load from above (Donald Bastow, 2004).

The three crucial element of a suspension system are as follows:

1. Flexibility, provided by a spring that distorts and recovers (typically compresses and expands) as the wheel traverses disturbances in the road surface.
2. Damping, which is essential to restrain the body and wheel from resonant bouncing motions.
3. Location of the wheel or axle.

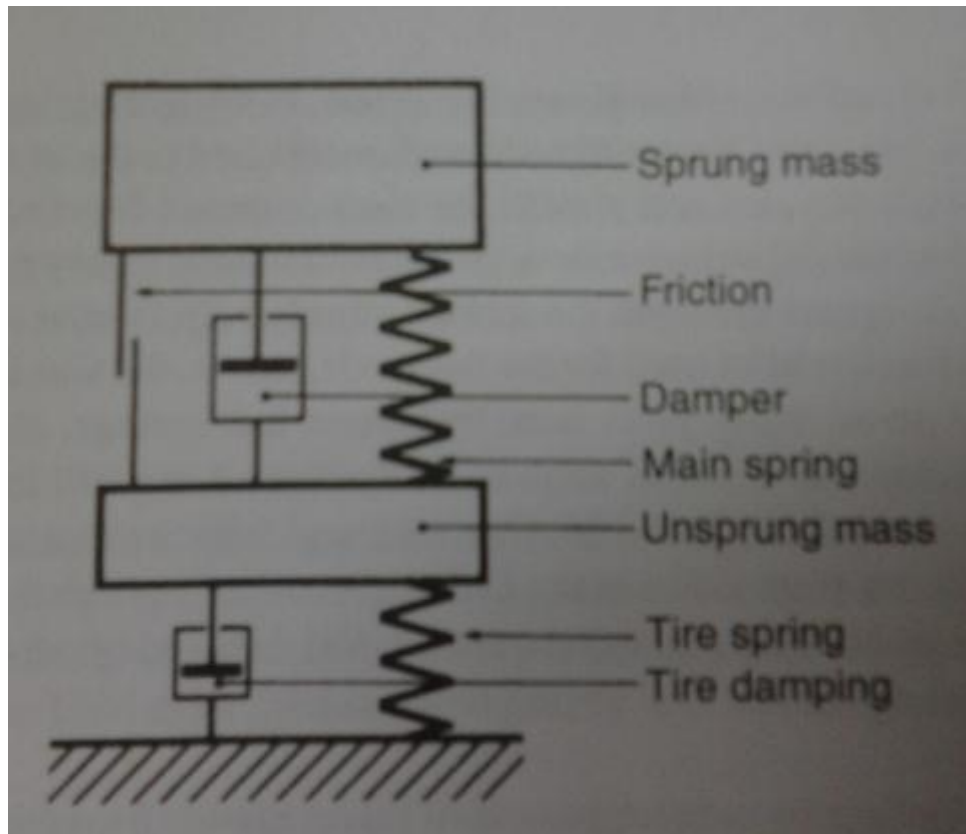


Figure 2.1 Suspension Systems

Figure 2.1: Vehicle suspension systems contain several elements, with a main spring supporting the sprung mass and the damper dissipating the energy stored in the spring during movement. The tire acts as a secondary spring system, acting on both the unsprung mass of the suspension and the sprung mass of the loaded vehicle (Donald Bastow, 2004).

Majjad (1997) and Tan and Bradshaw (1997) addressed the problem of the identification of car suspension parameter. The necessity of trading off among the

conflicting requirements of the suspensions in terms of comfort and road holding led to the use of optimisation techniques.

Besides that, some authors (Chang and Wu, 1997), in order to improve the comfort, designed a suspension based on a biological, neuromuscular-like control system.

Whilst road holding and handling can be objectively quantified by the analysis of the dynamic equation of a vehicle, this is not the case with comfort, as it is an inherently subjective matter. Ride quality, driving pleasure and driving fun are concerned with passenger comfort and driver feeling in a moving vehicle.

Vibration transmitted to passenger originates from a host of causes, including, amongst others, road unevenness, aerodynamic forces and engine and powertrain induced vibration. Road irregularities are indeed the major source of vibration. In a comfortable vehicle, vibration must stay within some boundaries. In order to establish these boundaries, it is firstly necessary to assess and quantify how to measure comfort. (Emanuele Guglielmino, 2008).

Several criteria have been proposed over the past to assess comfort based on the nature of the vibration. Some of them are general purpose whilst others are employed in specialist fields such as off-road and military vehicles (Pollock and Craighead, 1986).

One first criterion, relevant to the automotive field, is Janeway's comfort criterion (SAE Society of Automotive Engineers, 1965). It relates the comfort to vertical vibration amplitude and permits to find the largest allowed chassis displacement for each frequency. In essence it states that within the range 1-6 Hz the maximum allowable amplitude is the one resulting in a peak jerk value of not more than 12.6 m/s^3 . In other words, if X is the maximum allowed displacement amplitude and ω the angular frequency, Janeway's criterion states that:

$$X \omega^3 = 12.6 \quad (1.1)$$

2.3 VIBRATION

The most general criterion however is the standard ISO 2631 (1978); it is a general standard applicable not only to vehicles but to all vibrating environments. It defines the exposure limits for body vibration in the range 1-80Hz, defining limits for reduced comfort, for decreased proficiency and for preservation of health.

If vibration are applied in all three directions (foot-to-head, side-to-side, back-to-chest), the corresponding boundaries apply for each component. Subsequently to the ISO standard and in 1998 Griffin thoroughly reviewed both of them, analysis merits and their weakest points.

Another criterion proposed is the vibration dose value (Griffin, 1984) which provides an indication based on the integral of the fourth power of the frequency-weighted acceleration. The vibration dose (VD) value is calculated as:

$$VD = \int_0 a^4 dt. \quad (1.2)$$

Where VD is the vibration dose values and the a is the value of the acceleration for this equation (Emanuele Guglielmino, 2008).

2.4 COIL SPRING

The use of the coil spring as the primary suspension medium generally appeared only with the increasing trend toward independent front suspension after World War. The advantage offered by the coil spring is its almost total lack of internal friction, and this allows the damping function to be confined to a more precisely controlled damper unit.

Coil spring, although much more efficient in their ability to store energy and deflect through large displacements, need to react against member vertically above their input pads. Also, unlike leaf springs, coil spring do not provide axle or wheel location and therefore require separate suspension arms.

Thus, the concept of the coil spring is linked closely to the use of the integral body (also termed unitary or monocoque, and that is chassis-less and provides the structure of the vehicle) or of a complex chassis (that is, one is three dimensional, to provide a high torsional stiffness that is not achievable with a simple, essentially two-dimension ladder frame chassis).

The primary function of a suspension system has changed little over the years, even if the understanding of its behaviour and the quality of its ride comfort have both made huge advances. A suspension spring is still required to absorb the shock loadings produced by bumps in the road surface, and it does this by being initially compressed and subsequently expands on the total mass of the car. The rate at which it energy is stored depends on the spring rate, or stiffness, and the rate at which it releases this stored energy is controlled by the natural frequency of the sprung system, typically in the range 1-1.5 Hz.

$$\text{Energy storage per unit volume for a leaf spring} = f^2 / 6E \quad (1.3)$$

$$\text{Energy storage per unit volume for a coil spring} = f^2 / 4G \quad (1.4)$$

Where f is the stress in the material and for the symbol of E is the young's modulus. For the symbol of the G is shear modulus from second equation (Donald Bastow, 2004).

Today, most (but not all) suspension designs employ coil spring in a variety of forms, typically used concentrically with telescopic damper struts (often referred to as coil-over-damper).

The flexibility of their design criteria and their ability to be manufactured relatively cheaply, in large quantities and with consistent characteristics, has brought coil spring to the forefront of modern suspension design. In the modern, highly optimized body shell, they also feed road loads into well-spaced and stiff areas of the engineering structure (Donald Bastow, 2004).

2.5 CHROMIUM STEEL

A lustrous, hard, steel-gray metallic element, resistant to tarnish and corrosion and found primarily in chromites. It is used in the hardening of steel alloys and the production of stainless steels, in corrosion-resistant decorative plating, and as a pigment in glass. Chromium does not tarnish in air, when heated it burns and forms the green chromic oxide. The Atomic Number of this element is 24 and the Element Symbol is Cr.

Chromium steel (Cr) (2.1)

Elements can be classified based on their physical states (States of Matter) e.g. gas, solid or liquid. This element is a solid. Chromium is classified as a "Transition Metal" which is located in Groups 3 - 12 of the Periodic Table. Elements classified as Transition Metals are generally described as ductile, malleable, and able to conduct electricity and heat. Nearly 75% of all the elements in the Periodic Table are classified as metals which are detailed in the List.

Occurrence of Chromium the ore from which all chromium compounds are made is chromites, or chrome iron ore (FeCr_2O_4). The element also occurs in small quantities in many other minerals, especially in crocoisite (PbCrO_4), in which mineral it was first discovered.

Chrome iron (FeCr_2O_4) (2.2)

Crocoisite (PbCrO_4) (2.3)

Chromium, like manganese, is very hard to reduce from its ores, owing to its great affinity for Oxygen. It can, however, be made by the same methods which have proved successful with manganese. Considerable quantities of an alloy of chromium with iron, called ferrochromium, are now produced for the steel industry.

Properties of Chromium are a very hard metal of about the same density as iron. It is one of the most infusible of the metals, requiring a temperature little short

of 3000° for fusion. At ordinary temperatures air has little action on it; at higher temperatures, however, it burns brilliantly (Lange's Handbook of Chemistry (1952)).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter will describe further on the experiment which is design the new dimension of the spring, test the dimension spring and analysis the suspension system performance. In order to complete the experiment, methodology is one of the importance things that need to be considered. The objective of the methodology is to make sure that the project is running on schedule and the data obtained from the experiment can later be analysed.

In this chapter, all the details and related discussion on the process and methods that involved in the project are described. The process and timeline of the project is illustrated using flow chart and Gantt chart. Both charts are fundamental for this project as both charts explained every step to achieve the objective of the project. The project start with working on literature review and the end by submitting the complete report to the faculty after make a correction.

3.2 PROJECT FLOWCHART

Figure 3.1 shows the flow chart of every process that needed to complete the project. In the beginning, the project starts with understanding the title, determining the project scope and general background of the project.

Then, the literature review of the project is being made. All the sources for the information of the literature review came from the books, journal and from the

internet. Besides that, the data and information from the previous research can be used to gain new idea and concept to be used in the project. The information for the project is more cleared and understood better after done literature review process.

After that the computer modelling for the new model of the spring is needed. Firstly, we design the new dimension of the spring using software SolidWorks®. After that, we want to analysis the spring after we give the force on the each spring we use the MSC. Nastran/Patran software.

The stress analysis was carried out to analysis of stress of the spring. The highest amount of stress the spring can withstand the hardest spring. This process will do for each type of spring. So, we can make the comparison of stress result for each spring with different dimension.

The result from the analysis was discussed. If the stress value from the testing did not satisfy the objective and scope of the project, the testing is repeated to get the desired results. After the objective and scope of the project were fulfilled, the next step of the project is to present the Final Year Project to the panels. Final step of the project is to compile and submit the complete report of the project to faculty.

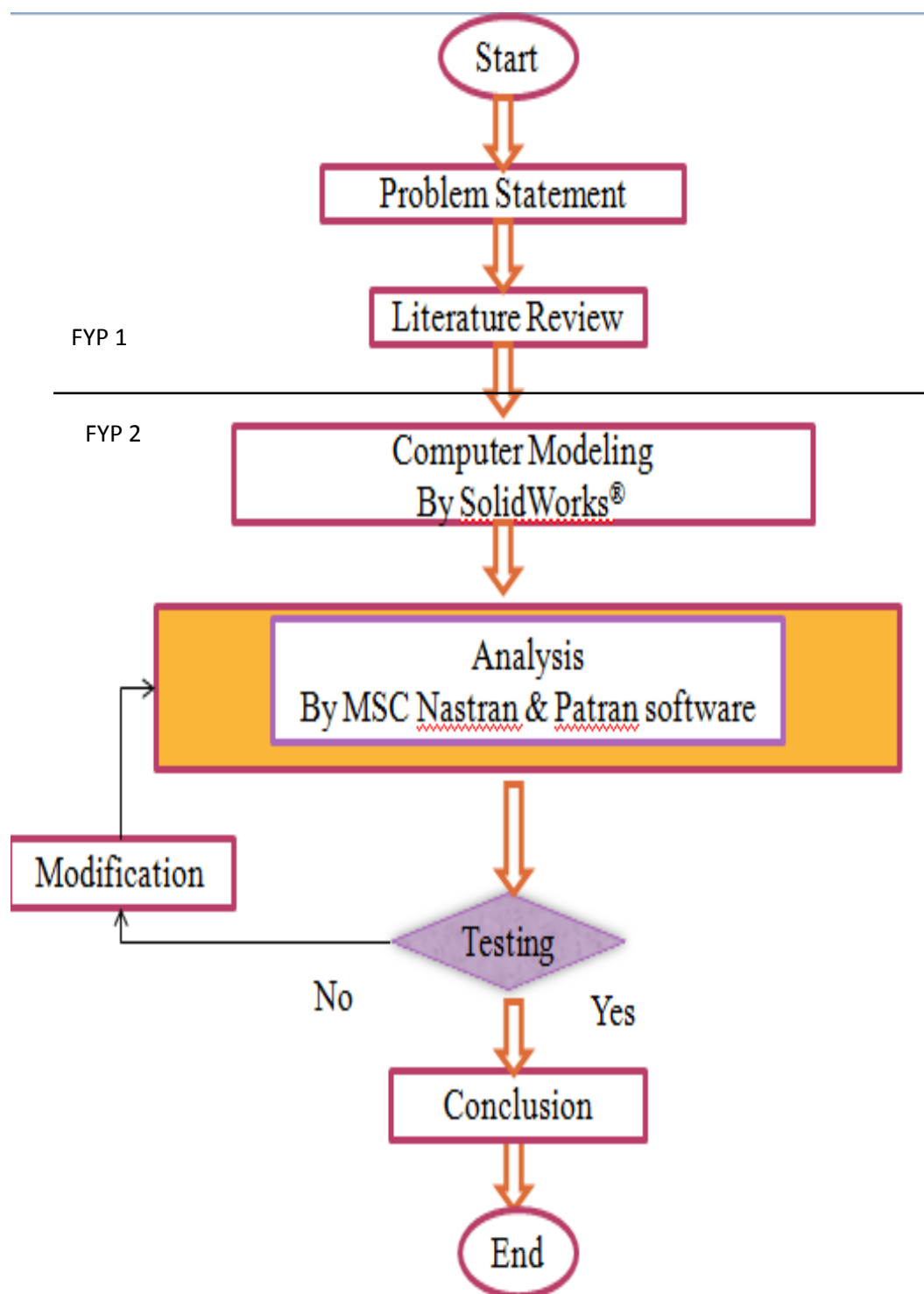


Figure 3.1: Framework of methodology.

3.3 MEASUREMENT TOOL

This is the measurement tool that we used to measure the dimension of the original value of the spring at the automotive laboratory of Universiti Malaysia Pahang. The dimension we used the manual reading as shown in the picture below.

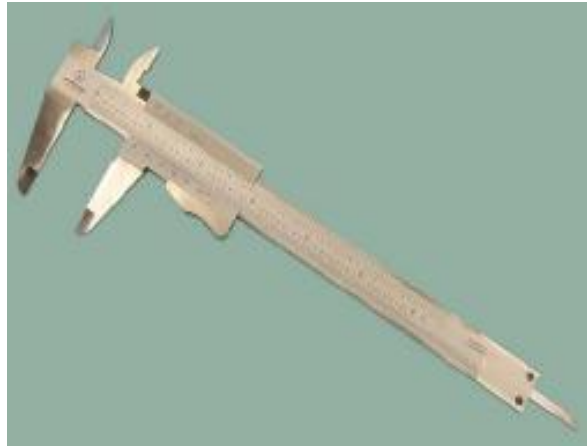


Figure 3.2: Vernier caliper –has a movable scale that is parallel to a fixed scale



Figure 3.3: Teletape-has adjustable tape that can use depend on the scale of workpiece.

3.4 ACTUAL DESIGN OF THE SPRING

This is the actual dimension of the spring that we already choose. This is the spring of the vehicle made from our country. The spring of vehicle that we choose as the project is PROTON SAGA 1998.



Figure 3.4: The actual spring picture.

Figure 3.5 as we shown in the below is the picture of the actual spring that is drawn using SolidWorks®.

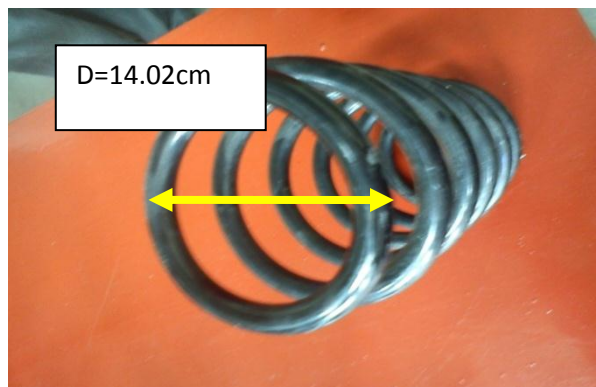


Figure 3.5: Drawing of the actual spring using SolidWorks®.

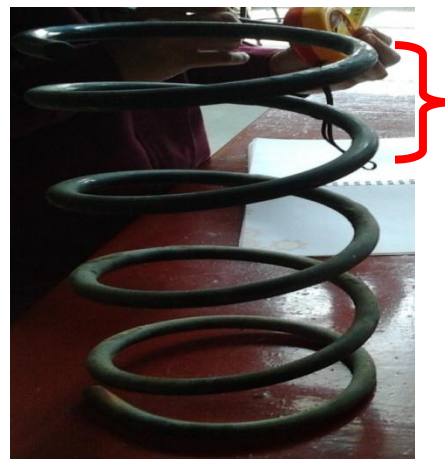
3.5 PARAMETER OF THE SPRING

The parameter of the spring such as force, types of material, mechanical properties is needed this is because to prevent for any mistake or to avoid the regardless during make the analysis of project. These parameters were used as the input for the stress analysis that we need to do into our project.

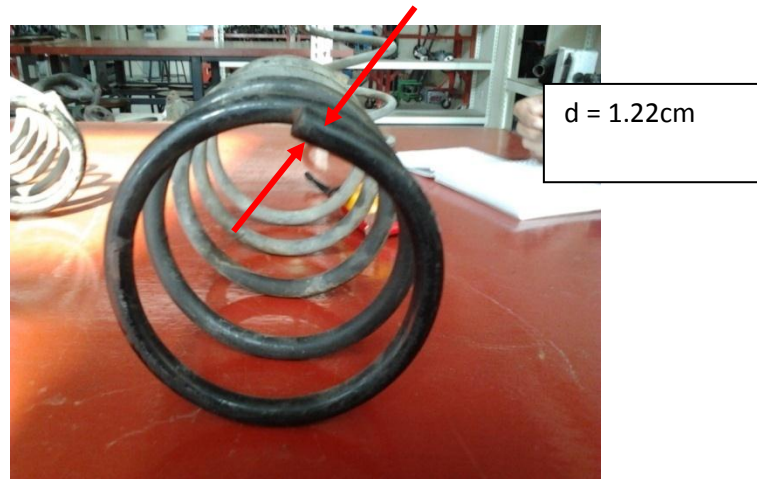
3.5.1 Variable



(a)



(b)



(c)

Figure 3.6: The dimensions and images for the actual spring a) spring diameter, D , b) spring pitch, l_1 , and c) wire diameter, d .

3.5.2 Constant

All the parameter, such as the types of the material we used for the spring, the total length of the spring, and the mechanical properties is the important thing in our project. To get the good result, we must constant the force to require the valid stress result from the stress analysis.

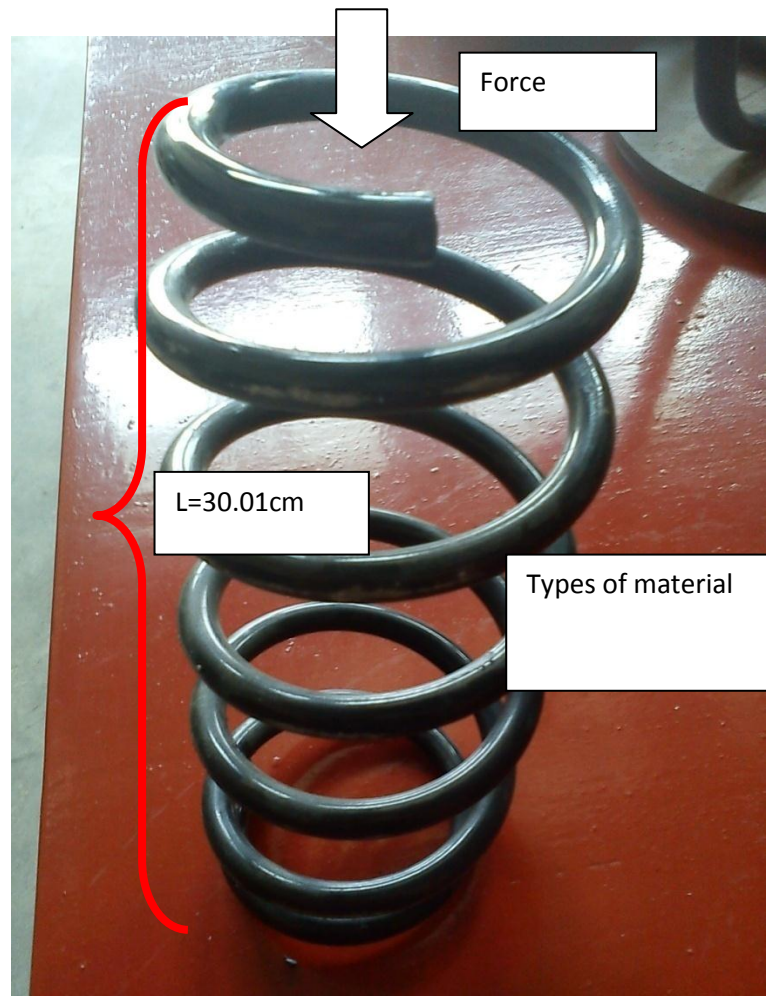


Figure 3.7: This is the dimension and the images for the actual spring and all the parameter that we need to consider before and during this project.

3.6 DESIGN OF THE DIFFERENT DIMENSION OF THE SPRING

3.6.1 First design

This is the original of the spring that we do not modify the dimension of the coil spring. This dimension of the spring we assume as the spring A as shown in Figure 3.5.

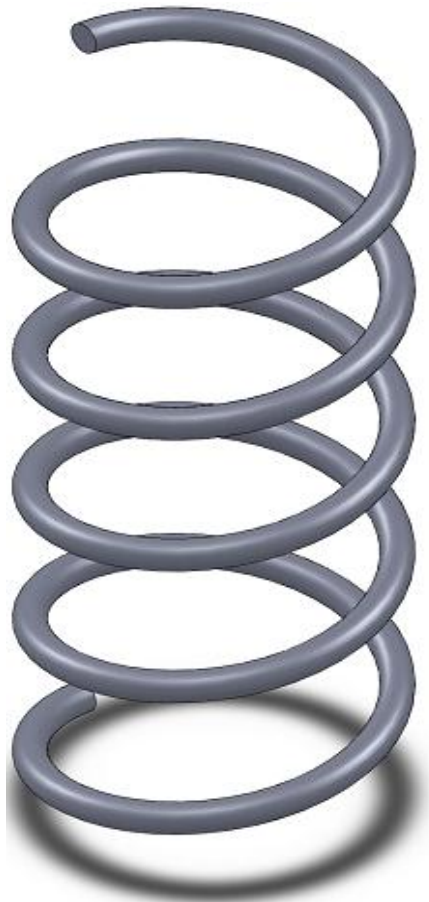


Figure 3.8: Spring A (actual spring).

3.6.2 Second design

This is the second of the spring that we modified the dimension of small diameter of the coil spring. This dimension of the spring we assume as the spring B as shown in Figure c.



Figure 3.9: Spring B (change the wire diameter, d).

3.6.3 Third design

This is the third of the spring that we modified the dimension of large diameter of the coil spring. This dimension of the spring we assume as the spring C as shown in Figure a.

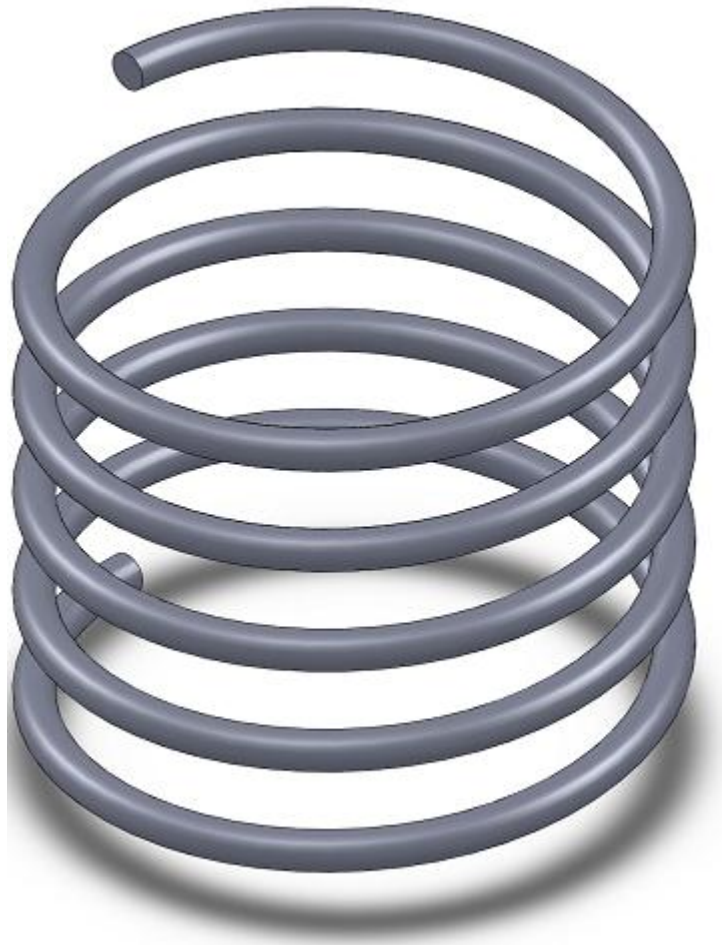


Figure 3.10: Spring C (change the diameter of the spring, D).

The detail dimension for each spring is shown in Table 3.1.

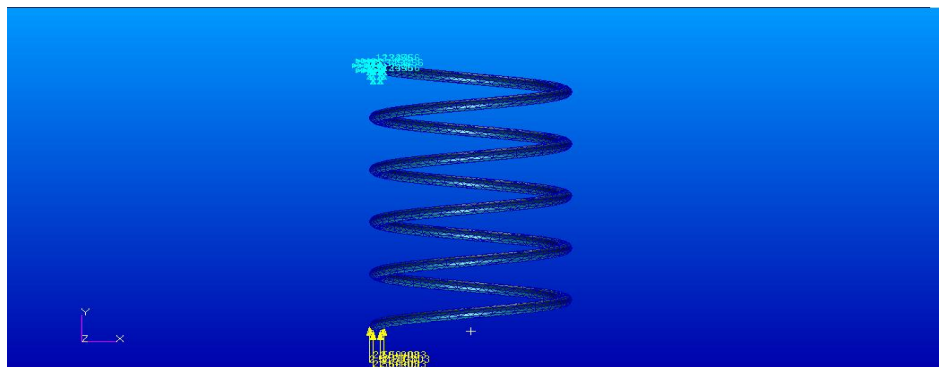
Table 3.1: This is the detail value of dimension of the spring that we need to do the stress analysis.

No.	Types of the spring	Parameter		
		L	d	D
1.	A	30.01cm	30.01cm	30.01cm
2.	B	1.22cm	2.00cm	1.22cm
3.	C	14.02cm	14.02cm	15.00cm

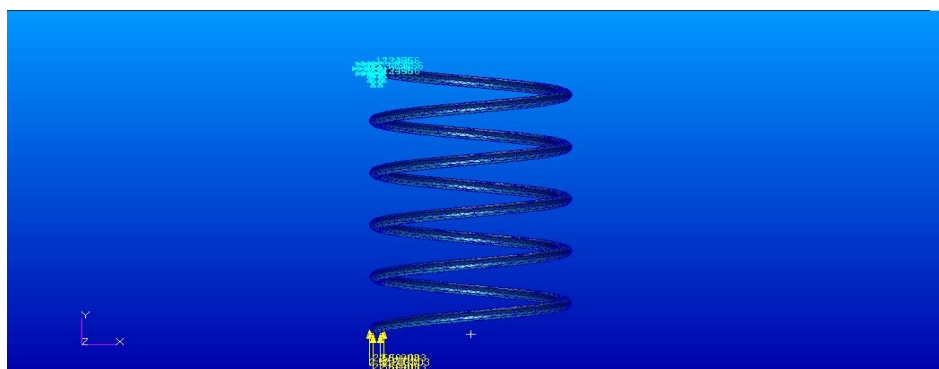
3.7 STRESS ANALYSIS

The stress analysis that we do in this project which is using the MSC. Nastran/Patran software. This analysis must be import the SolidWorks® drawing into the Patran and then fill up all the data required for Patran software.

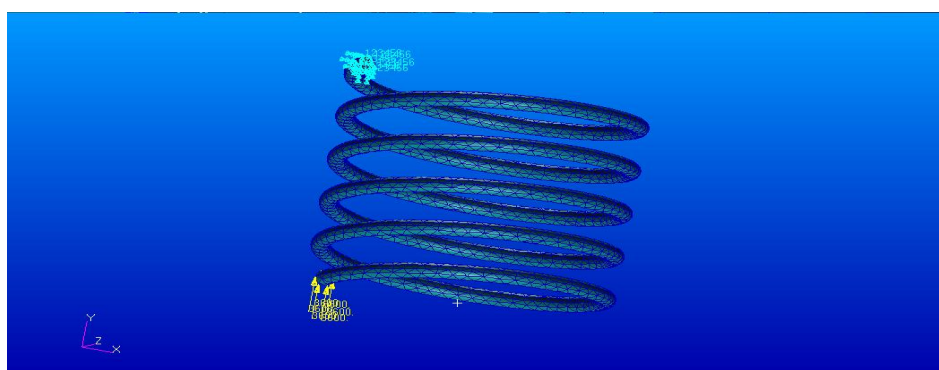
After that, to get the result of the stress on the spring we must access the stress analysis first. But for this below images, this is the meshing picture of the spring for each spring. These meshing pictures are the first step after we import from the SolidWorks® software into the MSC.Nastran/Patran software.



(A) Original design



(B) Second design



(C) Third design

Figure 3.11: The meshing result for the a) spring A, b) spring B, and c) spring C.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter present result of this project and later on, the results are discussed in details. In this project, the result obtained by using experimental method which is analyzing the effect of the dimension spring to the suspension system by the stress sensor. The recommendation for this project will be discussed in the next chapter.

4.2 STRESS ANALYSIS RESULTS

All the data is importance to get the comparison between the springs. When the stress applied to the spring, we can get the result of the amount of stress on the spring. We used MSC. Nastran/Patran software, to get the stress result. The types of the spring and the diameter of the spring we can get from the previous table, (Table 3.1).